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Cognitive and behavioral modeling techniques for CGFs: A new initiative.

Denise Lyons, Ph.D.
Naval Air Warfare Center Training Systems Division
Code 4962: Training Technology
12350 Research Parkway
Orlando, FL 32826-3224
407-380-4819
lyonsdm@navair.navy.mil

Harold Hawkins, Ph.D.
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217
703-696-4323
hawkinh@onr.navy.mil

ABSTRACT: *A recent NRC report [1] identified that a shortcoming in the area of military simulations is the lack of behavioral realism in computer generated forces (CGFs). Given the military's growing reliance on large-scale simulations as a means to prepare our warfighting teams, this deficiency has far reaching consequences. Therefore, ONR and NAWCTSD are launching a research initiative to investigate cognitive and behavioral modeling (CBM) techniques suitable for injecting into executable models of combatant behavior. In particular, it is necessary to devise robust strategies for simulating higher-order processes in CGFs including decision making, intent, deception, adaptability, creativity and problem solving. This initiative will be executed in three phases. Phase 1: Develop a taxonomy that describes military simulation applications and modeling methodologies with a common set of discriminating features/attributes to study the technical capabilities and shortcomings of current CGFs and CBMs. Phase 2: Convene a multi-disciplinary panel of experts at a workshop to validate the findings and provide feedback. The results will be published as guidelines to advance, implement and apply CBM techniques for CGFs. Phase 3: Based on the initial findings, this initiative will facilitate the application of CBM methodologies currently viable for military simulation, implement hybridization of CBM techniques that provide part of a solution and invest in CBM advancements where insufficient theory exists.*

1. Introduction

The increasing use of simulations for military training, mission rehearsal, analysis, acquisition, and command decision aiding applications, together with their extension into the domain of joint operations, places far greater expectations on the output of the underlying models than originally intended. In particular, most synthetic force models within military simulations have been constructed using relatively primitive human models in which the richness of behavior and decision-making are represented in only a coarse and brittle manner. This has produced simulated opponent and allied forces with unrealistic behavior and simplistic responses that do not correspond to the behavior of real individual soldiers or units [1].

Advances in the psychological, organizational and sociological sciences have produced a large body of knowledge in human behavior and cognition that to date has been incorporated only minimally into computer generated forces (CGFs). A multi-phased program has been established to facilitate the inclusion of this science in CGFs towards improved realism of military simulations.

2. Background

As the capabilities of modeling and simulation technologies are demonstrated, as in the Synthetic Theater of War (STOW) exercises, an increasing number of military programs that incorporate this technology are generating requirements for improved human behavior representations. These programs extend across a wide range of applications, including training, acquisitions and analysis:

- Large scale training system architectures such as the Battle Force Tactical Trainer (BFTT), Joint Countermine Operational Simulation (JCOS), Distributed Mission Trainer (DMT) and the future Joint Simulation System (JSIMS) use a synthetic

battlespace populated with a combination of semi-automated forces (SAFs) and live entities serving as adversaries and friendly forces.

- The SC21 Manning Affordability initiative is demonstrating the use of cognitive and behavioral models for human centered design, simulation based acquisition and automated decision aids.

- The JCOS and DMT programs are utilizing SAFs for analysis, mission planning and rehearsal, as well as for training

Each of these applications places a unique set of requirements and priorities on the performance of CGFs. Understanding these differences is essential for determining which cognitive and behavioral modeling (CBM) approach will provide improved behavioral representation to current SAFs most effectively and efficiently.

1. Phase 1: The Study

To bring model developers and simulation architects to a common understanding of these issues, a study is underway to: 1) identify and define a list of relevant and discriminatory features that may be used to evaluate CGFs and CBM methodologies; 2) analyze the relative importance and impact of each modeling attribute to military simulation applications; and 3) analyze the strengths and weaknesses of current modeling techniques with respect to each of these attributes.

The results will be described as a taxonomy, for developers of CGFs and CBM techniques, intended to provide a common frame of reference; an understanding of the interplay between military simulation environments and specific behavioral representations; and increase communication among the various disciplines that contribute to the modeling and simulation enterprise.

The following provides an initial list of issues to be addressed:

- Application strengths - applications for which each approach, or straightforward extensions of it, are best suited, and why.

- Aggregation/de-aggregation capability and ease - how easily can the approach be exploited to represent cognition/action at differing echelons and at the platform vs. individual combatant levels?

- Computational complexity/agent attribute - what computational costs are incurred in enhancing the behavioral/cognitive realism of agents or specific agent attributes yielded by the approach?

- Explanatory potential - ability to incorporate into the architecture the capability to provide explanation of decisions and actions as a training device.

- Flexibility in granularity - extent and ease with which the approach enables the builder/user to modify the detail with which agents or specific agent attributes are represented, so that less relevant or unimportant attributes can be represented only grossly, or not at all, and more relevant attributes can be represented in fine grain.

- Hybridization potential - potential for the approach to be combined with others to exploit the strengths of both to create more fully elaborated agent behaviors (e.g., combining EPIC and Soar or COGNET, or evolutionary and AI-based algorithms).

- Interoperability - capability and ease with which the agent capabilities created through the approach can be interfaced within simulation environments.

- Realism enhancement potential - the ability and ease with which the approach can be exploited to create agents with interesting perceptual/ cognitive/ motor capabilities of interest, including learning from experience, reasoning, planning, responsivity to fatigue and stress, performance variability and unpredictability, perceptual/ mnemonic/ cognitive fallibility, and the like.

- Usability - ease with which the approach can be used by the builder/user to create or modify agents.

4. Phase 2: A Workshop

The initial findings of the study will be presented to the modeling and simulation community during a one-day workshop sponsored by ONR and NAWCTSD (date and location TBD). A multi-disciplinary panel of expert psychologists, computer scientists and military specialists will be convened to discuss the taxonomy, provide feedback and make recommendations. Results will be published as guidelines to advance, implement and apply CBM techniques for CGFs.

It is envisioned that this report will guide decisions for future collaboration between CGF and CBM developers, illuminate research areas ripe for

immediate payoffs with short-term investment, and direct attention to research areas that need substantial long-term investment.

5. Phase 3: Conduct Research

Based on the initial findings, this initiative will facilitate the application of CBM methodologies currently viable for military simulation, implement hybridization of CBM techniques that provide part of a solution, and invest in CBM advancements where insufficient theory exists.

For maximum impact and adaptability, multiple directions will be taken to interject CBMs into CGFs. Approaches include: cognitive, perceptual or behavioral software modules that can be integrated directly into the behavior representation of SAFs, stand alone models that serve as automated forces such as an automated teammate in a training simulator, and decision making agents that can reduce the number of role-players or "SAF Masters" required for a simulated exercise.

6. Summary

One of the Navy's long range planning objectives [2] is to "Exploit modeling and simulation technology to enhance operational readiness and to permit affordable, realistic training to be conducted at the multi-unit, unit, and individual level with less underway time and reduced requirements for target or support services." The NRC Panel on Representing Human Behavior in Military Simulations determined that there is a need to improve the behavioral representation in CGFs to fulfill such objectives.

A new initiative has been developed to address issues specific to applying cognitive and behavioral modeling methodologies within CGFs used in current military simulation applications. Results and guidelines from this research will bring us closer to realizing fully automated, realistically behaving simulated forces that will provide worthy adversaries and intelligent friends in virtual and constructive simulations for training, mission planning and rehearsal, analysis, acquisition and command decision aiding.

7. References

[1] Pew, R. W., Mavor, A. S., *Modeling human and organizational behavior: application to military simulations,* National Academy Press, Washington, D.C. 1998.

[2] CNO's Navy Long Range Planning Objectives 02 Mar 98.

Author Biographies

DR. DENISE LYONS is a Senior Research Engineer in the Science and Technology Division of the Naval Air Warfare Center Training Systems Division. Her current focus includes modeling and simulation, and training technology for programs in Improved Behavioral Representation of Computer Generated Forces (CGF), Shipboard Instructor Training and Support (SITS) and the Advanced Embedded Training System (AETS). She received her Ph.D. in Optical Sciences from the University of Arizona, and has over 10 years of experience in research and development for military systems.

DR. HAROLD HAWKINS manages programs at the Office of Naval Research that fund basic and applied research in human/cognitive modeling for computer generated forces. He also manages programs in computational vision, auditory computation, and biosonar. The dominant theme in all these programs is to increase the fidelity and computational utility of models derived from understanding of biological systems, and exploiting these models in the design of engineered systems to address Navy requirements. He received a Ph.D. in Cognitive Psychology at the University of Oregon, and spent 19 years on the faculties of the University of South Florida and the University of Oregon, teaching and conducting research in human cognition, perception, and human factors psychology. He joined ONR in 1985.